

1

PERIPHERAL TREATMENT FOR HEAD-MOUNTED DISPLAYS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of co-pending U.S. patent application Ser. No. 11/580,774, filed on Oct. 13, 2006, which is hereby incorporated herein by reference in its entirety.

BACKGROUND

This invention relates to displaying images in a head-mounted display. A head-mounted display (HMD) is a display device that a person wears on the head in order to have video information directly displayed in front of the eyes. HMDs are also known as near-to-eye displays. A HMD has either one or two small CRT, LCD or OLED displays with magnifying lenses and other associated optical elements. The display(s) and optics are typically embedded in a helmet, glasses, or a visor, which a user can wear. Lenses and other optical components are used to give the user the perception that the images are coming from a greater distance, to prevent eyestrain. In HMDs that use a single display, the image is typically projected through optics that split the image into two identical images, and redirects each image to the respective eye. With two displays, the HMD can show stereoscopic images. The stereoscopic images attempt to create depth to the images by simulating the angular difference between the images viewed by each eye when looking at an object, due to the different positions of the eyes. This angular difference is one of the key parameters the human brain uses in processing images to create depth perception or distance in human vision.

Some HMDs can be used to view a see-through image imposed upon a real world view, thereby creating what is typically referred to as an augmented reality. This is accomplished by reflecting the video images through partially reflective mirrors, such that the real world is seen through the mirrors' reflective surfaces. The augmented reality can be combined with the stereoscopic images in various types of applications. Some examples include applications in surgery, where radiographic data, such as CAT scans or MRI imaging can be combined with the surgeon's vision. Military, police and firefighters use HMDs to display relevant tactical information, such as maps or thermal imaging data. Engineers and scientists use HMDs to provide stereoscopic views of CAD schematics, simulations or remote sensing applications. Consumer devices are also available for use in gaming and entertainment applications.

FIGS. 1A-1D show some exemplary schematic views of different HMD display architectures. FIG. 1A shows an example of a transmissive HMD display architecture. In this architecture, a white light source, such as a white LED illuminates a liquid crystal display (LCD) that displays an image to a user. The image is then relayed to the user's eyes through an optical system, which can be either an aspherical or diffractive lens system. Such lens systems are well known to those of ordinary skill in the art and will also be discussed in further detail below.

FIG. 1B shows an example of an emissive HMD display architecture. In this architecture, the display is an Organic Light Emitting Diode (OLED) display, and thus a separate light source can be avoided. The image is then relayed to the user's eyes through an optical system, similar to the system described above with respect to FIG. 1A.

2

FIG. 1C shows an example of a reflective HMD display architecture. In this architecture, the display is a Liquid Crystal on Silicon (LCoS) display. In LCoS, liquid crystals are applied to a reflective mirror substrate. A light source, such as a white or RGB LED directs light onto the LCoS display. As the liquid crystals in the display open and close, the light is either reflected from the mirror below, or blocked. This modulates the light and creates the image. The image is then relayed to the user's eyes through an optical system, similar to the system described above with respect to FIG. 1A.

FIG. 1D shows an example of a Micro-electro-mechanical (MEM)/Laser display architecture for a HMD. MEM devices are devices that are capable of constructively and destructively interfering with an incident light source to produce one or more optical signals. Optical MEM devices are typically fabricated from Silicon-based materials using lithographic techniques. Optical MEM devices have reflective ribbons that are formed over a suitable substrate structure, such that the ribbons are spatially arranged in parallel and are coupled to the substrate structure. In use, portions of the reflective ribbons are moved by applying an operating bias voltage, or switching voltage, across the ribbons and the substrate structure. By alternating, or switching, the potential of the bias voltage, the ribbons are alternated between the positions for constructive and destructive interference with the incident light source to generate optical signals. As can be seen in FIG. 1D, the light source is a laser, and the resulting optical signals from the MEM devices are displayed on an image surface and viewed by the user.

A problem with HMDs, primarily HMDs that are not of the see-through kind, is that the image on the display in front of each eye fills the central but not the peripheral field of view of the user. Consequently, the visual experience is similar to looking into a box or tunnel having a small screen at a distance. Peripheral vision is good at detecting motion and as a result, occluded peripheral vision in HMDs can cause a user to experience motion sickness symptoms after some time. Thus, whereas existing HMDs may work well for their intended purposes for short periods of time, there is a continuing need for improved HMDs that provide enhanced long-time visual experience for the user.

SUMMARY

The present invention provides methods and apparatus for treating the peripheral area of a user's field of view in a head mounted display, and thereby creating improved comfort and usability for head mounted displays. The peripheral area adjacent to the displayed image is treated, such that the peripheral area is coordinated with the image on the display. The coordination can be in the form of color projections, achieved, for example, by light emitting diodes (LEDs) or other displays, such that the colors surrounding the display dynamically matches what is shown on the display. As a result, the peripheral area "converges" with the display area, which reduces the "tunnel effect" or "box effect" experienced by the user. Various embodiments of the invention allow users to customize different viewing parameters of the head mounted displays to accommodate for variation in the individual users' eyes.

In general, in one aspect, the invention provides methods and apparatus, including computer program products, implementing and using techniques for projecting a source image in a head-mounted display apparatus for a user. A first display projects an image viewable by a first eye of the user. A first peripheral light element is positioned to emit light of one or more colors in close proximity to the periphery of the first display. A receives data representing a source image,